Table 4. Pearson's correlation coefficient (r) between antioxidant activities of fractions from mango Ataulfo and bioactive compounds contents.

	ABTS	FRAP	ORAC
Ascorbic acid	**0.745** 0.021	**0.813** 0.008	**0.756** 0.018
β-carotene	**0.705** 0.034	**0.764** 0.017	**0.692** 0.039
Mangiferin	**0.886** 0.001	**0.832** 0.005	**0.895** 0.001
Quercetin	**0.786** 0.012	**0.698** 0.037	**0.783** 0.013
Apigenin glucoside	**0.847** 0.004	**0.760** 0.017	**0.830** 0.006
Quercetin 3-O-rhamnoside	**-0.067** 0.863	**-0.191** 0.623	**-0.083** 0.831
Luteolin 7-O-glucoside	**0.780** 0.013	**0.694** 0.038	**0.774** 0.014
Ferulic acid	**0.998** 0.00	**0.970** 0.00	**0.992** 0.00
Quinic acid	**0.993** 0.00	**0.965** 0.00	**0.984** 0.00
Galic acid	**0.938** 0.00	**0.953** 0.00	**0.990** 0.00
Coumaric acid	**0.909** 0.00	**0.919** 0.00	**0.960** 0.00

(TE)= Trolox equivalent, ABTS (free radical of 2,2'-azinobis-(3-ethylbenzothiazoline-6 sulfonic acid); FRAP (ferric reducing ability of plasma); ORAC (oxygen radical absorbance capacity).

DISCUSSION

The present research focused on comparing the nutraceutical potential of three mango Ataulfo by-products based on their nutritional and phytochemical profiles and *in vitro* antioxidant activity. Mango Ataulfo fruit is a good source of macro and micronutrients like other fruits; regular consumption can provide significant requirements of vitamins, minerals, dietary fiber, energy, and a minor supply of protein and fat. The U.S. Food and Drug Administration (FDA) recommends a daily vitamin C value of 90 mg for adults; thus, 10 g of mango Ataulfo pulp or peel provides 74% and 100 % of vitamin C, respectively [40].

Excessive sugar consumption is associated with obesity, metabolic disorders and chronic degenerative diseases. The WHO recommends limiting the intake of foods with a high content of available sugars to prevent sugar intake from exceeding 10% of total energy intake [41]. The high sugar content in mango pulp makes its use limited in nutritional programs, however, precisely the proven beneficial effects of mango consumption in the prevention of metabolic disorders, diabetes and cardiovascular diseases seem to contradict this paradigm. There is controversy between those who propose a greater consumption of fruits and those who suggest limiting the consumption of fruits rich in fructose such as mango, since fructose has been associated with a higher incidence of diseases such as hepatic steatosis, cardiovascular diseases and cancer [42].

On the other hand, the combination of dietary fiber and available sugars characteristic of fruits such as mango, confers it a low glycemic index. The higher proportion of dietary fiber and lower glycemic index is related to a decrease in molecular markers of inflammation [43]. Mango peel had a better nutritional profile than the pulp, as it contains fewer available sugars and significantly higher dietary fiber content, suggesting that it has a lower glycemic index. Compared to pulp, mango peel also contained considerably higher amounts of all bioactive compounds evaluated (vitamin C, provitamin A, phenolic acids, flavonoids and mangiferin).

The beneficial properties of mango are due to the abundance of phytochemicals with structures that promote ROS scavenging and that intervene positively in reducing or inhibiting the production of proinflammatory cytokine [14-15,23]. Therefore, it would be expected that the differences in the composition of the mango fractions evaluated could exert different biological functionalities depending on the natural combination of bioactive compounds they contain; future research work could be oriented in that direction.

The study of the chemical composition of mango peel has gained relevance in recent years because it is an abundant source of bioactive compounds wasted during industrial mango processing. The comparison of Ataulfo, Tommy Atkins, and Keitt mango peels highlights the Ataulfo cultivar as the most prominent source of dietary fiber and total phenolics [44]. The content of flavonoids and phenolic acids in the peel of Ataulfo mango was also higher than that of Haden, Manila, and Panamanian mango [27].

Despite the large number of studies on the beneficial effects of mango bioactive compounds, a recent and extensive systematic review states that there is not enough scientific evidence to support that mango consumption is effective as an antidiabetic in humans; it also suggests that the effect of the different varieties of mango used in the investigations; differences in nutritional composition and bioactive compounds are likely to contribute to the discrepancy on results [45].

Mango peel fiber is a dietary fiber concentrate derived from the solvent extraction of soluble components. The peel fiber isolated from mangoes represents a good quality source of dietary fiber, considering the balance in the proportion of soluble and insoluble fiber that characterizes it. This by-product of mango could be useful to enrich low-fiber foods and increase their technological and nutraceutical functionality [30]. Adequate consumption of dietary fiber is associated with decreased blood cholesterol, lower risk of CVD, and a healthier gut microbiota [5,46].

The differences in the composition of the various mango cultivars or the different parts of the mango fruit become relevant when used in experiments to observe some physiological effects. When a certain portion of mango pulp or peel is established in an experiment, the dose of the components that will impact the study model is based. In the same way, the quantification of nutritional and bioactive compounds of the different parts of the Ataulfo mango (pulp, peel, and peel fiber) will allow subsequent interventional research to determine doses of bioactive compounds.

ABTS, ORAC, and FRAP antioxidant capacity tests are considered biologically relevant and are widely used, as they collectively assess hydrophilic, lipophilic, and reducing potential in both foodstuffs and biological systems under physiological conditions. The results of the three antioxidant capacity tests did not indicate a predominant antioxidant mechanism in the different Ataulfo mango products. This is possibly due to interactions between the different antioxidants and potent reducing compounds in Ataulfo mango products. In this sense, the antioxidant activity and the *in vitro* results confirmed the superior potential of the functionality of mango peel with respect to mango pulp and peel fiber. These results confirm those previously reported when compared nine mango varieties [47]. The

results of the correlation between antioxidant capacity and the different bioactive compounds are also consistent with those reported for mango peel and kernel [28]. We agree with these authors that mango peel is an ideal ingredient to be used in the preparation of functional foods that help improve overall health. In this regard, work has been done adding mango peel powder to the preparation of some processed foods such as bread and yogurt [48-49].

Mango peel also represents an important source for the extraction of specific compounds such as mangiferin. Mangiferin is perhaps the mango component with the most research regarding extraction and purification methods [21,50], therapeutic effects [51-52], mechanisms of action [53,54] and pharmaceutical forms [24-25,55]. Another compound abundant in mango peel is quercetin, which could be explored as a nutraceutical, since it is the most abundant flavonoid in mango peel and its remarkable antioxidant capacity has been widely proven on inflammatory and metabolic disorders [56-57]. However, further studies are required to support the requirements to be considered as a functional food ingredient [58].

In summary, the results of this work showed that mango Ataulfo peel is a promising combination of high diversity and quantity of bioactive compounds like dietary fiber, vitamins, and phytochemicals, all of which have proved to have beneficial health functionalities; the mango Ataulfo pulp, on the other hand, offers both bioactive compounds and sugars that could contribute to raising the sensory and nutraceutical quality of foods. Nutritional and chemical characterization allowed us to know the proportion of the different compounds in the natural state of each part of the mango fruit.

CONCLUSIONS

The composition of mango peel offers a rich combination of mangiferin, flavonoids, phenolic acids, vitamin C, provitamin A, and dietary fiber, all of them associated with the prevention of diseases related to inflammation and oxidative stress. These results support the exceptional nutraceutical potential of mango peel due to its superior antioxidant capacity.

Furthermore, its high dietary fiber content suggests potential health benefits due to the well-known properties of dietary fiber to stimulate the growth of beneficial gut bacteria, regulate blood sugar levels and reduce cholesterol.

It is highly recommended to conduct some *in vivo* studies in the near future to demonstrate whether the consumption of these three different mango by-products will actually improve the symptoms of diseases related to inflammation and oxidative stress, according to their respective nutritional and nutraceutical composition and antioxidant capacity.

Abbreviations: ROS: reactive oxygen species; HPLC: High performance liquid chromatography; TEAC: Trolox Equivalent Antioxidant Capacity; FRAP: Ferric Reducing Antioxidant Power; MPF: peel isolated fiber.

Competing interests: The authors declare no conflict of interest.

Acknowledgment: The authors thank MC. Pedro Bastidas and Dra. Laura Contreras for their valuable technical support in chromatographic analysis, and MC Cristina Alicia Elizalde for its support in antioxidant capacity tests.

Authors´ contributions: Conceptualization, MVJ, JAS and RVR; writing, RVR, JAS and MVJ; writing—review and editing, JAS, MVJ, CCQ; supervision, CCQ, FCT, ETC; project administration, MVJ and JAS. All authors have read and agreed to the published version of the manuscript.

REFERENCES

1. FAO. Major Tropical Fruits Market Review 2023 [https://www.fao.org/markets-and-trade/publications/detail/es/c/1708896/]. Retrieved September 24, 2024.

2. Noriega Juárez AD, Rubio Carrillo JD, García Magaña ML, González Aguilar GA, Meza Espinoza L, Chacón López MA, et al.: Comparison of individual quick freezing and traditional slow freezing on physicochemical, nutritional and antioxidant changes of four mango varieties harvested in two ripening stages. Food Chem Adv. 2024, 1:100590. DOI: https://doi.org/10.1016/j.focha.2023.100590
3. Sabuz AA, Molla MM, Khan MHH, Chowdhury MGF, Pervin S, Alam M, et al.: Comparison of physicochemical composition, antioxidant activity and common phytochemicals of selected BARI mango varieties and commercial cultivar, Langra. Food Chem Adv. 2024,1:100580. DOI: https://doi.org/10.1016/j.focha.2023.100580
4. Campos V, Tappy L, Bally L, Sievenpiper JL, Lê KA: Importance of carbohydrate quality: What does it mean and how to measure it? J Nutr. 2022, 152:1200–1206. DOI: https://doi.org/10.1093/jn/nxac039
5. Siddiqui H, Sultan Z, Yousuf O, Malik M, Younis K. A review of the health benefits, functional properties, and ultrasound-assisted dietary fiber extraction. Bioactive Carbohydrates and Dietary Fibre. 2023, 30:100356. DOI: https://doi.org/10.1016/j.bcdf.2023.100356
6. Ye S, Shah BR, Li J, Liang H, Zhan F, Geng F, et al.: A critical review on interplay between dietary fibers and gut microbiota. Trends Food Sci Tech. 2022, 124:237–49. DOI: https://doi.org/10.1016/j.tifs.2022.04.010
7. Asuncion P, Liu C, Castro R, Yon V, Rosas M, Hooshmand S, et al.: The effects of fresh mango consumption on gut health and microbiome – Randomized controlled trial. Food Sci Nutr. 2023, 11:2069–2078. DOI: https://doi.org/10.1002/fsn3.3243
8. He Y, Wang B, Wen L, Wang F, Yu H, Chen D, et al.: Effects of dietary fiber on human health. Food Sci Hum Wellness. 2022, 11:1–10. DOI: https://doi.org/10.1016/j.fshw.2021.07.001
9. Li X, Wang L, Tan B, Li R: Effect of structural characteristics on the physicochemical properties and functional activities of dietary fiber: A review of structure-activity relationship. Int J Biol Macromol. 2024, 269:132214. DOI: https://doi.org/10.1016/j.ijbiomac.2024.132214
10. Rosas M, Pinneo S, O'Mealy C, Tsang M, Liu C, Kern M, et al.: Effects of fresh mango consumption on cardiometabolic risk factors in overweight and obese adults. Nutr Metabol Cardiovasc Dis. 2021, 32:494-503. DOI: https://doi.org/10.1016/j.numecd.2021.11.001
11. Yahia EM, Ornelas-Paz J de J, Brecht JK, García-Solís P, Maldonado Celis ME: The contribution of mango fruit (*Mangifera indica* L.) to human nutrition and health. Arab J Chem. 2023, 16:104860. DOI: https://doi.org/10.1016/j.arabjc.2023.104860
12. Castro RJ, Pedroza K, Hong MY: The effects of mango consumption on vascular health and immune function. Metabol Open. 2023, 20:100260. DOI: https://doi.org/10.1016/j.metop.2023.100260
13. Mukherjee A, Ghosh KK, Chakrabortty S, Gulyás B, Padmanabhan P, Basu Ball W: Mitochondrial reactive oxygen species in infection and immunity. Biomolecules 2024, 14:670. DOI: https://doi.org/10.3390/biom14060670
14. Miazek K, Beton K, Śliwińska A, Brożek-Płuska B: The effect of β-carotene, tocopherols and ascorbic acid as antioxidant molecules on human and animal *in vitro*/*in vivo* studies: A review of research design and analytical techniques used. Biomolecules. 2022, 12:1087. DOI: https://doi.org/10.3390/biom12081087
15. Reang J, Sharma PC, Thakur VK, Majeed J: Understanding the therapeutic potential of ascorbic acid in the battle to overcome cancer. Biomolecules. 2021, 11:1130. DOI: https://doi.org/10.3390/biom11081130
16. Christodoulou MC, Orellana Palacios JC, Hesami G, Jafarzadeh S, Lorenzo JM, Domínguez R, et al.: Spectrophotometric methods for measurement of antioxidant activity in food and pharmaceuticals. Appl Sci. 2022, 13:4076. DOI: https://doi.org/10.3390/app13074076
17. Zagoskina N V., Zubova MY, Nechaeva TL, Kazantseva V V., Goncharuk EA, Katanskaya VM, et al.: Polyphenols in plants: Structure, biosynthesis, abiotic stress regulation, and practical applications (Review). Int J Mol Sci. 2023, 24:13874. DOI: https://doi.org/10.3390/ijms241813874
18. Elgadir MA, Chigurupati S, Mariod AA: Selected potential pharmaceutical and medical benefits of phenolic compounds: Recent advances. Functional Food Science. 2023. 3(7):108–128. DOI: https://www.doi.org/10.31989/ffs.v3i7.1118
19. El-Saadony MT, Yang T, Saad AM, Alkafaas SS, Elkafas SS, Eldeeb GS, et al.: Polyphenols: Chemistry, bioavailability, bioactivity, nutritional aspects and human health benefits: A review. Int J Biol Macromol. 2024, 277:134223. DOI: https://doi.org/10.1016/j.ijbiomac.2024.134223
20. Castro-Muñoz R, Cabezas R, Plata-Gryl M: Mangiferin: A comprehensive review on its extraction, purification and uses in food systems. Adv Colloid Interface Sci. 2024, 329:103188. DOI: https://doi.org/10.1016/j.cis.2024.103188

21. Kaurav M, Kanoujia J, Gupta M, Goyal P, Pant S, Rai S, et al.: In-depth analysis of the chemical composition, pharmacological effects, pharmacokinetics, and patent history of mangiferin: Mangiferin as herbal medicine with diverse therapeutic activities. Phytomed Plus. 2023, 3:100445. DOI: https://doi.org/10.1016/j.phyplu.2023.100445
22. Martirosyan D, Lampert T, Lee M. A comprehensive review on the role of food bioactive compounds in functional food science. Functional Food Science. 2022, 3(2):64–78. DOI: https://doi.org/10.31989/ffs.v2i3.906
23. Minniti G, Fornari Laurindo L, Mendes Machado N, Gonsalves Duarte L, Landgraf Guiguer E, Cressoni Araujo A, Aparecido Dias J, et al.: *Mangifera indica* L., by-products, and mangiferin on cardio-metabolic and other health conditions: A Systematic review. Life. 2023,13:2270. DOI: https://doi.org/ 10.3390/life13122270
24. Wang Y, Karmakar T, Ghosh N, Basak S, Gopal Sahoo N: Targeting mangiferin loaded N-succinyl chitosan-alginate grafted nanoparticles against atherosclerosis – A case study against diabetes mediated hyperlipidemia in rat. Food Chem. 2022, 370:131376. DOI: https://doi.org/10.1016/j.foodchem.2021.131376
25. Foudah AI, Ayman Salkini M, Alqarni MH, Alam A: Preparation and evaluation of antidiabetic activity of mangiferin-loaded solid lipid nanoparticles. Saudi J Biol Sci. 2024, 31:103946. DOI: https://doi.org/10.1016/j.sjbs.2024.103946
26. Barrón-García OY, Morales-Sánchez E, Ramírez Jiménez AK, Antunes-Ricardo M, Luzardo-Ocampo I, González-Jasso E, et al.: Phenolic compounds profile and antioxidant capacity of 'Ataulfo' mango pulp processed by ohmic heating at moderate electric field strength. Food Res Int. 2022, 154:111032. DOI: https://doi.org/10.1016/j.foodres.2022.111032
27. Pacheco Jiménez AA, Lizardi Mendoza J, Heredia JB, Gutiérrez Grijalva EP, Quintana Obregón EA, Muy Rangel MD: Physicochemical characterization of pectin and mango peel (*Mangifera indica* L.) from Mexican cultivars. Heliyon. 2024, 10(15): e35184. DOI: https://doi.org/10.1016/j.heliyon.2024.e35184
28. Lebaka VR, Wee YJ, Ye W, Korivi M: Nutritional composition and bioactive compounds in three different parts of mango fruit. Int J Environ Res Public Health. 2021, 18:741. DOI: https://doi.org/10.3390/ijerph18020741
29. Lenucci MS, Tornese R, Mita G, Durante M: Bioactive compounds and antioxidant activities in different fractions of mango fruits (*Mangifera indica* L)., cultivar Tommy Atkins and Keitt). Antioxidants. 2022, 11(3):484. DOI: https://doi.org/10.3390/antiox11030484
30. Mehadi Galib R, Alam M, Rana R, Ara R: Mango (Mangifera indica L.) fiber concentrates: Processing, modification and utilization as a food ingredient. Food Hydrocoll Health. 2022, 2:100096. DOI: https://doi.org/10.1016/j.fhfh.2022.100096
31. Association of Official Analytical Chemists: Official Methods of Analysis. 20th Edited by George W. Latimer Jr. England: Oxford University Press; 2016.
32. Nikolidaki EK, Chiou A, Christea M, Gkegka AP, Karvelas M, Karathanos VT: Sun dried Corinthian currant (*Vitis vinifera* L., var. Apyrena) simple sugar profile and macronutrient characterization. Food Chem. 2017, 221:365–72. DOI: https://doi.org/10.1016/j.foodchem.2016.10.070
33. Gokmen V, Kahraman N, Demir N, Acar J: Enzymatically validated liquid chromatographic method for the determination of ascorbic and dehydroascorbic acids in fruit and vegetables. J Chromat A. 2000, 881:309-316. DOI: https://doi.org/10.1016/S0021-9673(00)00080-7
34. Gross J: Carotenoids. In: Pigments in Vegetables: Chlorophylls and Carotenoids. 1st edition. Edited by Gross J. New York: Springer; 1991:75–278. DOI: https://doi.org/10.1007/978-1-4615-2033-7
35. Shi L, Zhao W, Yang Z, Subbiah V, Suleria HAR: Extraction and characterization of phenolic compounds and their potential antioxidant activities. Environ Sci Pollut Res. 2022, 29:81112–81129. DOI: https://doi.org/10.1007/s11356-022-23337-6
36. Ojeda GA, Vallejos MM, Sgroppo SC, Sánchez-Moreno C, de Ancos B: Enhanced extraction of phenolic compounds from mango by-products using deep eutectic solvents. Heliyon. 2023, 9(6): e16912. DOI: https://doi.org/10.1016/j.heliyon.2023.e16912
37. Guo YP, Yang H, Wang YL, Chen XX, Zhang K, Wang YL, et al: Determination of flavonoids compounds of three species and different harvesting periods in *Crataegi folium* based on LC-MS/MS. Molecules. 2021, 26(6):1602. DOI: https://doi.org/10.3390/molecules26061602
38. Bernal-Millán M de J, Carrasco-Portugal M del C, Heredia JB, Bastidas-Bastidas P de J, Gutiérrez-Grijalva EP, León-Félix J, et al: Green extracts and UPLC-TQS-MS/MS profiling of flavonoids from mexican oregano (*Lippia graveolens*) using natural deep eutectic solvents/ultrasound-assisted and supercritical fluids. Plants. 2023, 12:1692. DOI: https://doi.org/10.3390/plants12081692
39. Munteanu IG and Apetrei C: Analytical methods used in determining antioxidant activity: A Review. Int J Mol Sci. 2021, 22(7):3380. DOI: https://doi.org/10.3390/ijms22073380
40. FDA, Food and Drug Administration, for Food Safety, Center Nutrition Applied. 2020. Daily Value and Percent Daily Value:

Changes on the New Nutrition and Supplement Facts Labels_Valor Diario y Porcentaje de Valor Diario: Cambios en las nuevas etiquetas de información nutricional y complementaria [www.FDA.gov/NewNutritionFactsLabel]. Retrieved September 25, 2024.

41. Yan RR, Chan CB, Louie JCY: Current WHO recommendation to reduce free sugar intake from all sources to below 10% of daily energy intake for supporting overall health is not well supported by available evidence. Am J Clin Nutr. 2022, 116:15–39. DOI: https://doi.org/10.1093/ajcn/nqac084
42. Febbraio MA and Karin M: "Sweet death": Fructose as a metabolic toxin that targets the gut-liver axis. Cell Metabolism. 2021, 33:2316–2328. DOI: https://doi.org/10.1016/j.cmet.2021.09.004
43. Qi XY, Chiavaroli L, Lee D, Ayoub-Charette S, Khan TA, Au-Yeung F, et al: Effect of important food sources of fructose-containing sugars on inflammatory biomarkers: A systematic review and meta-analysis of controlled feeding trials. Nutrients. 2022, 14:3986. DOI: https://doi.org/10.3390/nu14193986
44. Quintana Obregón E, San Martín Hernández C, Muy Rangel M, Vargas Ortiz M: Valoración de polvos de cáscara de mango (*Mangifera indica* L.) como una alternativa para la generación de alimentos funcionales. TIP Revista Especializada en Ciencias Químico-Biológicas. 2019, 22:1-5. DOI: https://doi.org/10.22201/fesz.23958723e.2019.0.178
45. Zarasvand SA, Mullins AP, Arjmandi B, Haley-Zitlin V: Antidiabetic properties of mango in animal models and humans: A systematic review. Nutr Res. 2023, 11:73–89. DOI: https://doi.org/10.1016/j.nutres.2023.01.003
46. Ye S, Shah BR, Li J, Liang H, Zhan F, Geng F, et al: A critical review on interplay between dietary fibers and gut microbiota. Trends Food Sci Technol. 2022. 124: 237–49. DOI: https://doi.org/10.1016/j.tifs.2022.04.010
47. de Sousa ASB, da Silva MCA, Lima RP, Meireles BRL de A, Cordeiro ATM, Santos EF da S, et al.: Phenolic compounds and antioxidant activity as discriminating markers and adding value of mango varieties. Sci Hortic. 2021, 287:110259. DOI: https://doi.org/10.1016/j.scienta.2021.110259
48. Zahid HF, Ali A, Legione AR, Ranadheera CS, Fang Z, Dunshea FR, Ajlouni S: Probiotic yoghurt enriched with mango peel powder: biotransformation of phenolics and modulation of metabolomic outputs after *in vitro* digestion and colonic fermentation. Int J Mol Sci. 2023, 24(10):8560; DOI: https://doi.org/10.3390/ijms24108560
49. Hasan MM, Islam MR, Haque AR, Kabir MR, Hasan SMK: Fortification of bread with mango peel and pulp as a source of bioactive compounds: A comparison with plain bread. Food Chem Adv. 2024, 5:100783 DOI: https://doi.org/10.1016/j.focha.2024.100783
50. Thakare VB, Jadeja GC, Desai MA: Extraction of mangiferin and pectin from mango peels using process intensified tactic: A step towards waste valorization. Chem Eng Res Des. 2023, 192: 280–288. DOI: https://doi.org/10.1016/j.cherd.2023.02.036
51. Maenpuena S, Meeudorn P, Pinthongc C, Athipornchai A, Phiwkaow K, Watchasit S: Mangiferin is a new potential antimalarial and anticancer drug for targeting serine hydroxymethyltransferase. Arch Biochem Biophys. 2023, 745:109712. DOI: https://doi.org/10.1016/j.abb.2023.109712
52. Rahmani AH, Almatroudi A, Allemailem KS, Alharbi HOA, Alwanian WM, Alhunayhani BA et al: Role of mangiferin in management of cancers through modulation of signal transduction pathways. Biomedicines. 2023, 11:3205. DOI: https://doi.org/10.3390/biomedicines11123205
53. Li Z, Pu Z, Gao Y, Zhou M, Zhang Z, Xiao P, et al.: Integrated serum and liver metabolomics decipher the hepatoprotective mechanisms of mangiferin sodium salt through modulating alcohol metabolism on alcoholic liver disease. Food Biosci. 2024, 61:104631 DOI: https://doi.org/10.1016/j.fbio.2024.104631
54. Fan X, Jiao G, Pang T, Wen T, He Z, Han J, Zhang F: Ameliorative effects of mangiferin derivative TPX on insulin resistance via PI3K/AKT and AMPK signaling pathways in human HepG2 and HL-7702 hepatocytes. Phytomedicine. 2023, 114:154740. DOI: https://doi.org/10.1016/j.phymed.2023.154740
55. Alkholifi FK, Alam A, Foudah AI, Yusufoglu HS: Phospholipid-based topical nano-hydrogel of mangiferin: enhanced topical delivery and improved dermatokinetics. Gels. 2023, 9:178. DOI: https://doi.org/10.3390/gels9030178
56. Cizmarova B, Hubkova B, Birkova A: Quercetin as an effective antioxidant against. Functional Food Science. 2023 3(3): 15-25 DOI: https://www.doi.org/10.31989/ffs.v3i3.1076
57. Janigashvili G, Chkhikvishvili I, Ratian L, Maminaishvili T, Chkhikvishvili D, Sanikidze T: Effects and medical application of plant-origin polyphenols: A narrative review. Bioactive Compounds in Health and Disease. 2024, 7(8):375-38. DOI: https://doi.org/10.31989/bchd.v7i8.1414
58. Martirosyan D, Stratton S: Advancing functional food regulation. Bioactive Compounds in Health and Disease. 2023, 6(7):166–71. DOI: https://www.doi.org/10.31989/bchd.v6i7.1178